GeoLogic Associates

Geologists, Hydrogeologists and Engineers

April 5, 2004
JN: 9539-65

Gregory Canyon Ltd.
991-C-404 Lomas Santa Fe Drive
Solana Beach, CA 92075

Attention: Mr. Richard Chase

**RE: LINER PERFORMANCE EVALUATION
PROPOSED COMPOSITE LINER SYSTEM
GREGORY CANYON LANDFILL**

INTRODUCTION

This letter report provides an evaluation of the expected performance of the composite liner system proposed for the Gregory Canyon Landfill in San Diego County, California. The proposed design includes a geocomposite clay liner (GCL) sandwiched between two high density polyethylene (HDPE) geomembrane layers, and on the floor areas (i.e., where the gradient is less than 5 to 1) a gravel or equivalent drainage layer on a third HDPE geomembrane layer, all of which will overlie a 2-foot thick low permeability clay layer. The proposed liner section will be placed on essentially uncompressible foundation materials and will be overlain by a prescriptive leachate collection and recovery system (LCRS) that will minimize the potential for leachate accumulation in the landfill prism.

This proposed liner system design includes the low-permeability and chemical resistance capabilities of the GCL (with a hydraulic conductivity of $<1x10^{-9}$ cm/sec), low-permeability clay (with a hydraulic conductivity of $<1x10^{-7}$ cm/sec), and HDPE geomembrane layers, with the conveyance and leak detection capabilities of the drainage layer. As designed, this liner system greatly exceeds the minimum "prescriptive" design standards for Class III solid waste sites as defined by California Code of Regulations Title 27 (CCR 27), and for Class I hazardous waste sites as defined in CCR 23.

The bottom liner system design, from top to bottom, includes the following elements:

- 24-inch-thick protective soil cover
- 12 ounce (oz.) non-woven geotextile
- 12-inch thick LCRS gravel layer
- 16 oz. non-woven geotextile
- 80-mil HDPE geomembrane, textured on both sides
- Non-woven geotextile-supported geocomposite clay liner (GCL)
- 60 mil HDPE geomembrane, textured on both sides
- 16 oz. non-woven geotextile
- 9-inch minimum thickness gravel or equivalent drainage layer, with a collection pipe

16885 W. Bernardo Dr., Suite 305, San Diego, CA 92127 Phone: (858) 451-1136 Fax: (858) 451-1087

- 16 oz. non-woven geotextile
- 60-mil HDPE geomembrane, textured on both sides
- 24-inch-thick layer of low hydraulic conductivity (<1x10-7 cm/sed) soil layer
- 12 oz. non-woven geotextile
- 12-inch-thick subdrain gravel layer

The slope liner system design (i.e., sections with gradients greater than 5 to 1), includes the following elements:

- 24-inch minimum thickness protective soil cover
- 16 oz. non-woven geotextile
- 80-mil HDPE geomembrane, single-sided textured (textured side down)
- Non-woven geotextile-supported geocomposite clay liner (GCL)
- 60 mil HDPE geomembrane, textured on both sides
- 24-inch-thick layer of low hydraulic conductivity ($<1x10^{-7}$ cm/sed) soil layer

DISCUSSION

The water quality protection afforded by the proposed landfill liner system offers significant enhancements compared to the prescriptive design included in 27 CCR. The relatively impermeable character of HDPE geomembranes, inclusion of both a primary (upper) and secondary geomembrane layer in a double-composite liner system, and a drainage layer underlain by a third geomembrane, significantly increases its protectiveness compared to the single geomembrane layer in the prescriptive design. Liner system elements and benefits are described below.

<u>Manufacturing and/or Construction Defects in Liner Materials</u>

As a result of improved geosynthetic manufacturing processes, and with the exception of physical defects, modern HDPE geomembranes are essentially impermeable. In addition, because of the extensive manufacturing quality controls, defects are typically identified early in the manufacturing process (often even before shipment of product) and manufacturing defects on installed liners have become relatively rare. Similarly, landfill liner construction today is typically performed by pre-qualified contractors working under the observation and testing services of qualified construction quality assurance (CQA) crews. As a result, construction-related defects are also unusual. In fact, using typical landfill construction protocols, manufacturing/construction-related defects in landfill liners are now infrequent and breeches are generally identified at densities of less than about 1 square centimeter per acre[1]. However, a thicker 80-mil HDPE geomembrane liner has been included in the design to provide added resistance to punctures or damage by surface construction activities following its placement.

[1] Schroeder, P.R., Lloyd, C.M., Zappi, P.A., and Aziz, N.M., 1994, The Hydrologic Evaluation of Landfill Performance (HELP) Model version 3, United States Environmental Protection Agency Office of Research and Development.

Given the probability that minor and relatively infrequent defects will be spatially distributed in both the primary and secondary geomembranes, it is highly unlikely that any defect in the primary geomembrane will directly overlie a defect in the secondary membrane. As a result, the relative performance of either liner will be governed largely by the potential for communication between the primary membrane defects and the secondary membrane defects (i.e., performance is measured as a function of how leachate migrates from an upper defect to a lower defect).

As published in an earlier liner performance demonstration (dated May 29, 2003), the transport time for leachate to travel through a 1 square centimeter leak in the primary geomembrane to a similar leak in the secondary geomembrane was calculated to take hundreds of years and the volume leachate available for infiltration through the secondary geomembrane defect would be minute (less than one milliliter per year). This calculation assumed that the maximum leachate head calculated by HELP3 analyses remains on the liner (3 inches or 0.25 feet) and assuming that the two geomembrane leaks are separated horizontally by 10 feet, as is proposed for the Gregory Canyon Landfill liner system design.

In summary, the proposed liner configuration provides substantial resistance to the downgradient migration of leachate to the drainage layer by incorporating a GCL in the potential pathway. As a result, the travel time from defect to defect is substantially increased and the total volume of leachate migrating through the primary membrane is substantially reduced. In fact, delivery of leachate from the primary geomembrane defect to the secondary geomembrane defects is calculated to take hundreds of years, and the volume of leachate available for infiltration through a secondary geomembrane defect would be minute.

Secondary Protection

For the Gregory Canyon Landfill liner configuration, even if leachate were to migrate through the primary and secondary liner, on the floor areas it will encounter a drainage layer of gravel or equivalent media bounded by a third HDPE liner at its base. The drainage layer with collection piping, designed to convey liquid by gravity to a dedicated storage tank, will remove the leachate (similar to the LCRS) and serve as a leak detection system to indicate if leachate has migrated beneath the encapsulated GCL. Beyond this drainage layer, the liner system also includes a continuous 2-foot thick layer of low permeability ($<1x10^{-7}$ cm/sec) material as a further barrier to keep leachate away from the liner subgrade.

As a result of the heavy equipment that is used to construct the LCRS and to deliver operations layer soils and overlying refuse, the most serious damage to liner systems often occurs after construction. In addition, considering the limited visibility that equipment operators have, such damage is often not recognized and can result in much larger breeches in the primary geomembrane than occur during construction. As stated above, the primary (top) geomembrane liner will be 80 mils, rather than the prescriptive 60 mil thickness to provide additional resistance to punctures and surface construction activities. As an additional aid in monitoring the integrity of the encapsulated GCL layers of the liner system, Gregory Canyon Limited has agreed to implement an electronic leak location survey as part of the final quality control for the upper geomembrane installation. The method is designed to identify holes in the geomembrane after the LCRS gravel and/or the protective soil cover layer has been placed. Any identified electrical anomaly will be investigated and the liner repaired as needed.

SUMMARY

The proposed liner configuration will afford significantly enhanced water quality protection compared to the prescriptive design included in CCR 27 for solid waste facilities or in CCR 23 (hazardous waste landfill regulations). The proposed liner configuration provides enhanced protection from both manufacturing/construction defects and post-construction damage to the liner with the low-permeability properties of the GCL in the proposed liner configuration working to isolate the leachate from the secondary geomembrane layer. As proposed, considering the slow velocity of leachate transport through the GCL, it may be hundreds or thousands of years before small volumes of leachate could be delivered to a defect in the secondary geomembrane. In the event that leachate is transmitted through the secondary geomembrane, as it enters the drainage layer it will be conveyed to a storage tank, and the tank will be monitored regularly as part of landfill operations and the quarterly water quality monitoring program. The drainage layer is underlain by a third HDPE geomembrane and as a final defense, a 2-foot thick low-permeability clay layer.

CLOSURE

This letter report has not been prepared for use by parties or projects other than those named or described above. It may not contain sufficient information for other parties or other purposes. This report has been prepared in accordance with generally accepted geotechnical practices and makes no other warranties, either expressed or implied, as to the professional advise or data included in it.

GeoLogic Associates

Sarah J. Battelle
Sarah J. Battelle, CHg
Vice President